US EPA Mid-Continent Ecology Division

Research Project Summary

Region 3 REMAP Project: A Small Watershed Characterization, Classification, and Assessment for West Virginia Utilizing EMAP Design and Tools

Overview

Most sources of stream impairment are related to nonpoint source pollution. To more efficiently deal with TMDL-related issues, we need an integrated approach to small watershed assessment, diagnosis, and restoration planning that is based on differences in sensitivity and probability of impairment among watershed classes (Fig. 1). A collaborative Regional-Environmental Monitoring and Assessment Program (R-EMAP)/Regional Applied Research Effort (RARE) project involving WV Department of Natural Resources (WV DNR), WV Department of Environmental Protection (WV DEP), US EPA Mid-Continent Ecology Division-Duluth, and US EPA Ecological Exposure Research Division-Cincinnati was developed to meet multiple needs for the State of West Virginia, including the testing of a watershed-based assessment framework. Objectives of the R-EMAP project were to:

1. Develop an index of biotic integrity (IBI) for fish communities specific to West Virginia's wadeable streams and small watersheds utilizing a probability based design:
-- Coldwater vs warmwater,
-- Landscape-based prediction of thermal regime;
2. Develop and test a small watershed characterization and classification system to explain variation in reference condition (400-40000 ha watersheds);
3. Establish a baseline for assessing biological impairments by identifying stressor impacts and small watershed vulnerability; and
4. Produce a "State-of-Streams" report (based on five years of statewide 305b data).

In Phase I of the project (year 2001), we developed and applied a probabilistic watershed-based sampling framework covering the Central Alleghany Plateau and portions of the Central Ridge and Valley Province ecoregions of West Virginia. We excluded subwatersheds of the Potomac River Basin even though they overlap with the Central Ridge and Valley Province, because of differences in biogeography and expectations for fish community diversity (Fig. 2). In Phase II of the project (year 2002), we developed andapplied a probabilistic watershed-based sampling framework for the Western Alleghany Plateau ecoregion (Fig. 3).

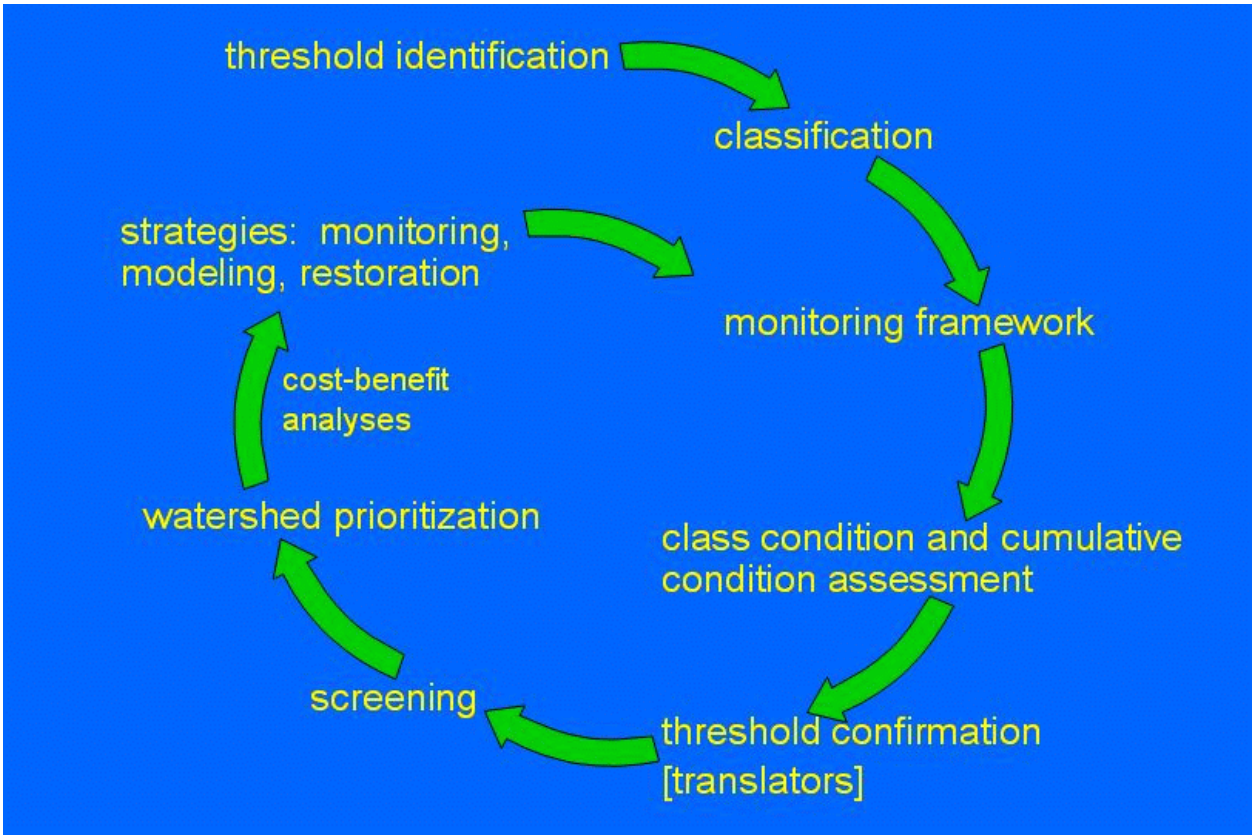
We used watersheds as our assessment unit to assess the effects of multiple nonpoint source stressors on biological condition. Watersheds were defined at the scale of 12-digit Hydrologic Catologing Units (HUCs; Fig. 4). Watersheds associated with 12-digit HUCs cover the entire range of sampling units (400-40000 ha watersheds) suitable for development of a fish IBI for wadeable streams in West Virginia. Hydrologic units include both basin and interbasin HUCs; the former define true watershed boundaries, while the latter define regions draining to consecutive segments of a river mainstem. Before assigning watershed characteristics to each 12-digit HUC, we first aggregated all upstream HUCs to define the associated drainage basin for that HUC.

For both stages of the project, we based the watershed classification framework on a combination of hydrology-moderating factors and intensity of land-use. We developed land-use based classes for each of the predominant land-use activities in each ecoregion using information from the literature identifying thresholds of land-use activity at which rapid degradation in biological or chemical condition is expected to occur. We defined separate land-use thresholds for gradients of agricultural, urban/residential, and mining activities. Based on analysis of long-term discharge records for US Geological Survey gauging stations in West Virginia, we identified appropriate hydrology-moderating factors and cut-off levels to distinguish among watershed classes. Drainage basin characteristics were examined to determine which distinguished among watersheds with stable versus flashy hydrologic regimes. For watersheds in the Central Alleghany Plateau and Ridge and Valley Provinces, we determined that watershed storage alone (fraction of watershed area covered by lakes and wetlands) was the best predictor of hydrologicregime (Fig. 5). For watersheds in the Western Alleghany Plateau, we determined that a combination of main channel length and watershed storage were the best predictors of hydrologic regime. Watersheds with low storage and/or short main channels (compressed vs. elongated watershed shape) had greater peak flows per unit watershed area.

For each ecoregion, sample watersheds were selected using a stratified-random approach from within high/low intensity land-use and watershed storage classes. Using EMAP and West Virginia DNR protocols, stream reaches at the base of each selected 12-digit HUC were sampled for water quality (pH, dissolved oxygen, conductivity, alkalinity, nutrients, major ions, and heavy metals), thermal regime, flow, habitat quality, and fish community condition (Fig. 6). Use of a probability-based sampling framework will enable us to summarize the physical, chemical, and biological condition across each ecoregion with a known level of uncertainty, while use of stratification in the sampling framework will allow us to compare probabilities of impairment among watershed classes based on physical, chemical, and/or biological condition.

RARE funding within this project supported the development of an IBI based on fish assemblages of West Virginia streams. The IBI will be provided to the State, along with scoring criteria adjusted for natural variability, for use in State biomonitoring and assessment programs. Currently, West Virginia is using benthic macroinvertebrates as its primary biomonitoring indicator. The existence of a defensible fish IBI will provide the State with an additional biomonitoring tool.

The success of the watershed classification framework for West Virginia is being tested against data collected from this project (water quality, thermal regime, habitat, fish communities) and other monitoring data collected in West Virginia (WV DEP data on water quality, macroinvertebrate communities, EMAP: Mid-Atlantic Highlands).


threshold identification
classification
monitoring framework
class condition and cumulative condition assessment
threshold confirmation [translators]
screening
watershed prioritization
cost-benefit analyses
strategies: monitoring, modeling, restoration
Figure 1

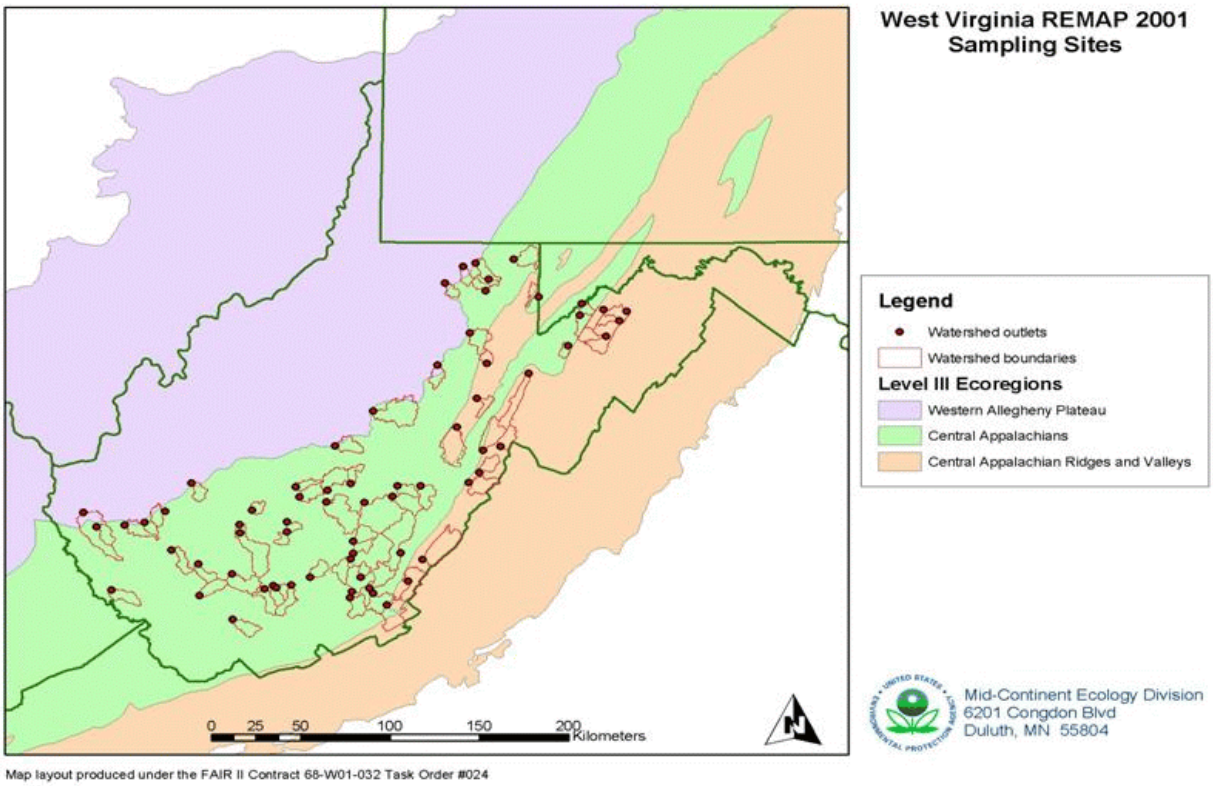

West Virginia REMAP 2001
Sampling Sites
Legend
Watershed outlets
Watershed boundaries
Level III Ecoregions
Western Allegheny Plateau
Central Appalachians
Central Appalachian Ridges and Valleys
0 25 50 100 150 200
Kilometers
N
Mid-Continent Ecology Division
6201 Congdon Blvd
Duluth, MN 55804
Map layout produced under the FAIR II Contract 68-W01-032 Task Order #024

Figure 2

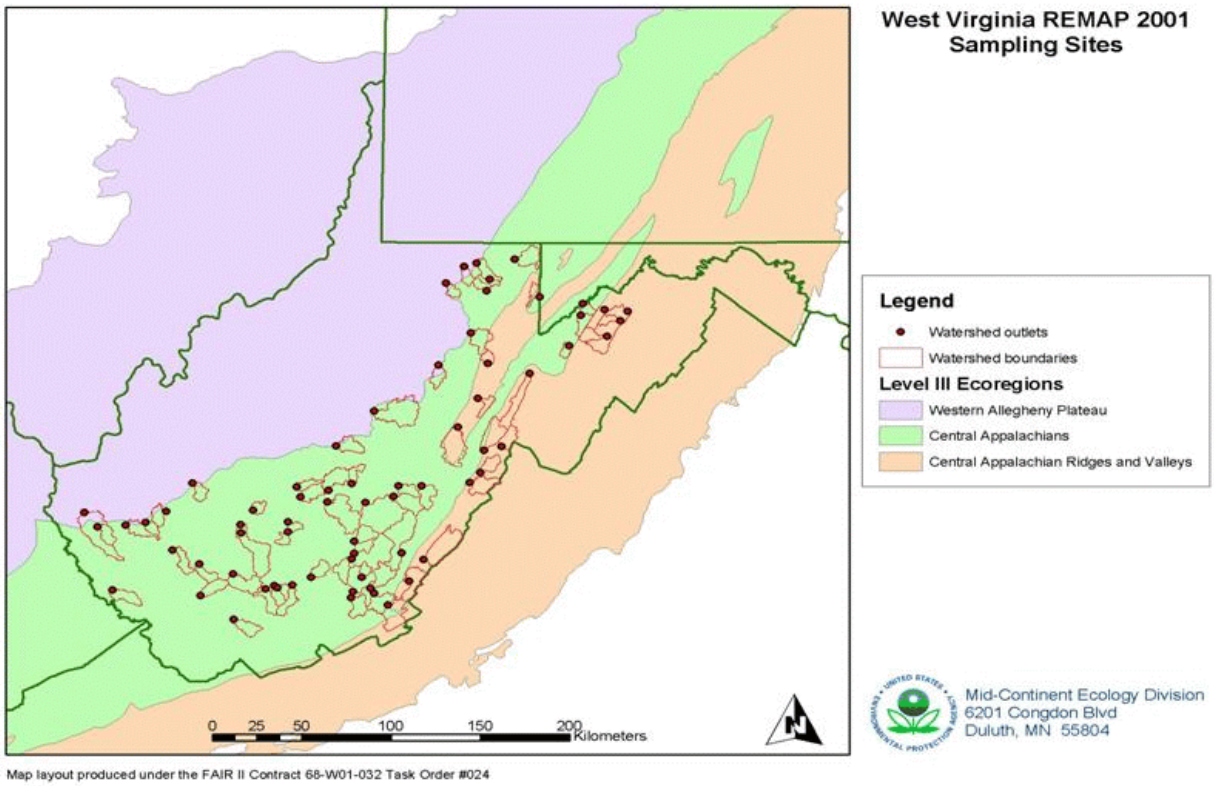

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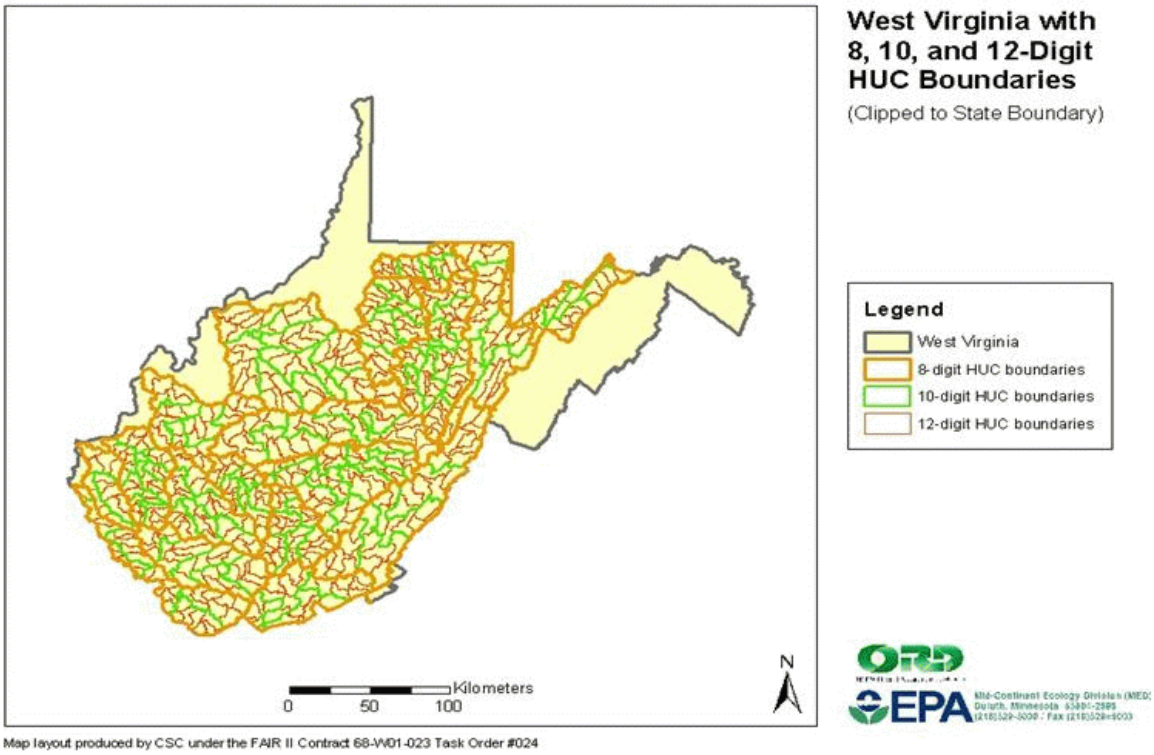
Figure 3



Map layout produced by CSC under the FAIR II Contract 68-W01-023 Task Order #024

Figure 4

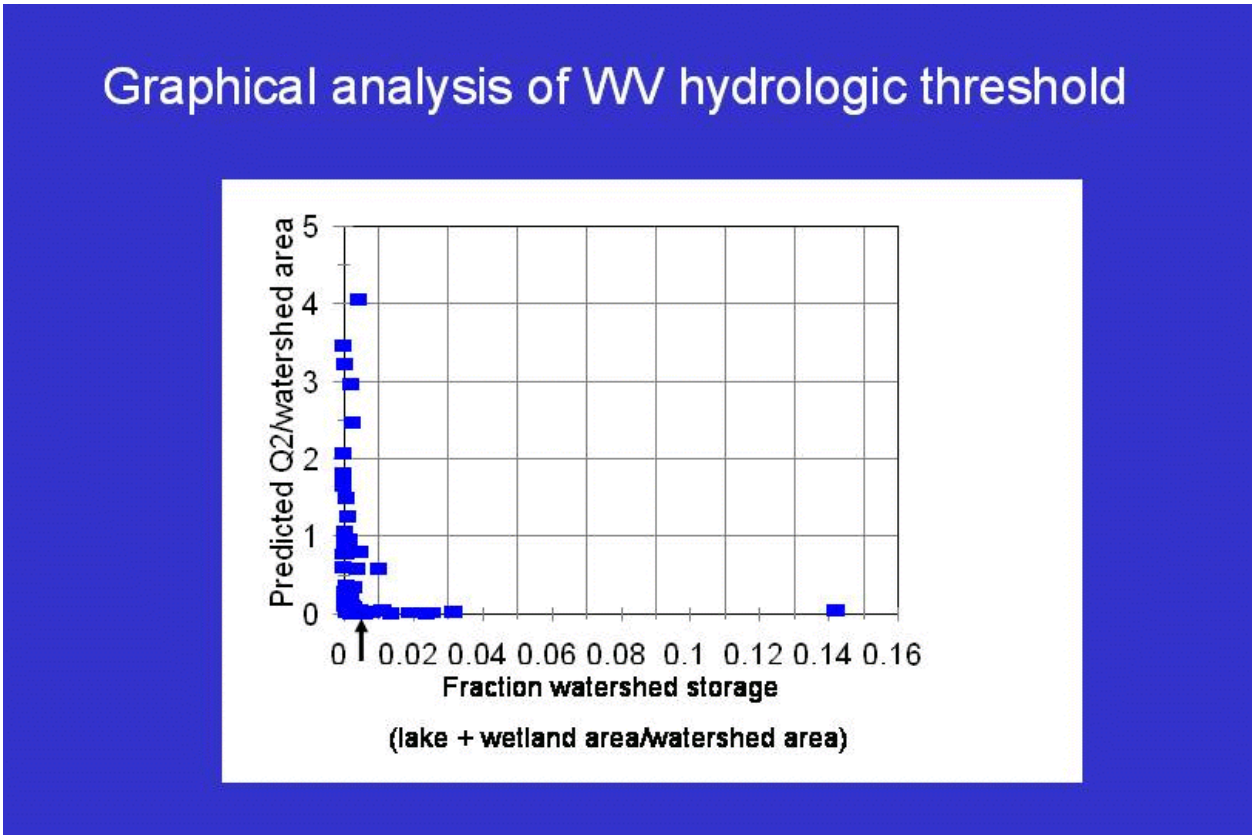

Graphical analysis of WV hydrologic threshold
Predicted Q2/watershed area
5
4
3
2
1
0
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
Fraction watershed storage
(lake + wetland area/watershed area)

Figure 5

Figure 6

Key Products

Detenbeck NE, Jagger LA, Stark SL, and Starry MA. 2003. WV REMAP Final Report: Watershed Classification Framework for the State of West Virginia. US EPA Report, National Health and Environmental Effects Laboratory, Mid-Continent Ecology Division, Duluth, MN. (In review)

Detenbeck NE, Cincotta D, Denver JM, Greenlee SK, and Olsen AR. 2003. Watershed-based survey designs. Submitted to Environ Monit Assess (special issue).

Future products:

Walters DM, et al. Development of a fish index of biotic integrity specific to West Virginia.

Detenbeck NE, et al. Test of a watershed-based classification and monitoring framework for West Virginia.

http://www.epa.gov/emap/remap/html/three/watershed.html

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